**Fatigue Risk Management in Aircraft Maintenance: An Update on a Complex Issue**

By Robert Baron, Ph.D

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## The British Airways Flight 5390 Incident

On June 10, 1990, British Airways Flight 5390, a BAC1-11, experienced a windscreen blowout shortly after departure from Birmingham International Airport in the United Kingdom. The left windscreen, which had been replaced prior to the flight, was blown out under effects of the cabin pressure when it overcame the retention of the securing bolts, 84 of which, out of a total of 90, were of smaller than specified diameter. The captain was sucked halfway out of the window and was restrained by cabin crew while the co-pilot flew the aircraft to a safe landing at Southampton Airport (Air Accidents Investigation Branch, 1992).

While the official accident report illuminated numerous contributing factors that led up to this incident, one of the most insidious factors was the effect of fatigue on the shift maintenance manager (SMM) who conducted the task. The work was conducted very early in the morning at a time when the human body experiences a natural low, also known as circadian (or time of day) effect. This, combined with lack of sleep before his shift, may have contributed significantly to the SMM's perceptual judgment error in selecting the wrong size bolts for the job and then justifying that decision by believing that the countersink was too big rather than the bolt was too small (Air Accidents Investigation Branch, 1992). This error may have been trapped if double checking and a pressure check were conducted. However, these procedures were not, and were not required to be, conducted at the time.

## Effects of Fatigue

Since the BAC1-11 incident there have been a number of maintenance-related accidents and incidents where AMT fatigue has been cited as a contributing factor. In this same period there has also been an exponential increase in research conducted on fatigue in aviation maintenance activities. Studies have shown that fatigue can have consequential effects on a person's cognitive ability. Cognition refers to mental processes such as awareness, perception, reasoning, and judgment.

Fatigue has drawn parallels to the effects of alcohol. Williamson, Feyer, Friswell, and Finlay-Brown (2000) studied driver fatigue and found that after 17 to 19 hours without sleep, performance on some tests was equivalent or worse than that at 0.05% BAC. Response speeds were up to 50 percent slower for some tests and accuracy measures were significantly poorer at this level of alcohol. After longer periods without sleep, performance reached levels equivalent to the maximum alcohol dose given to participants (0.1% BAC). The findings reinforced empirically that sleep deprivation is likely to compromise decision making ability and accuracy needed for safety on the road and in other industrial settings.

Federal Aviation Administration research has shown that aviation maintenance technicians routinely get less than the required 8 hours of sleep per night. In one study of aviation maintenance technicians, self-reported data indicated that participants slept an average

of 6 hours and 15 minutes per day. Sleep duration as measured with the Actiwatch sleep measurement device was estimated to be 5 hours and 7 minutes per day on average (Johnson, Hall, & Watson, 2002). These data, combined with other findings of the study, posited the following conclusions by the authors:

1. The assessment of sleep duration showed that the population of aviation maintenance technicians, throughout the industry, is sleep deprived.
2. This is a certain finding and represents a risk to safe work performance.
3. This statement is independent of age, experience, type of company, season of the year, etc., and it is exacerbated by shift work schedules.
4. Based on the data, low and insufficient sleep duration appears to be a cultural characteristic of the aviation maintenance workforce.
5. The questionnaire data strongly support the fact that this general pattern of insufficient sleep is not a result of extended work hours.
6. The combination of the measured data and the questionnaire data indicate that AMT's are not cognizant of the fact that they do not get enough rest. (p.16)

## FAA and NTSB Positions Differ on Fatigue Management

In light of this study, the FAA appears to be resistant to promulgating new regulations for the purpose of decreasing fatigue in the aviation maintenance environment. This has created somewhat of a dichotomy between the NTSB and the FAA. In fact, a reduction of accidents and incidents caused by human fatigue has been on the top of the NTSB Most Wanted list of aviation safety improvements for a number of years. The FAA response to the recommendation has, to date, been unacceptable (National Transportation Safety Board, 2009). The NTSB argument reads as follows:

> In 1999, the FAA issued a report, *Study of Fatigue Factors Affecting Human Performance in Aviation Maintenance*. The FAA expanded this study, completing the first phase of the expanded study and issuing a report in April 2000, titled *Evaluation of Aviation Maintenance Working Environments, Fatigue, and Maintenance Errors/Accidents*. The expanded study looked at multiple and combined environmental factors of temperature, noise, light, vibration, and sleep, which are known to accelerate fatigue onset, as well as the effects of lifestyle habits on fatigue and human performance. The study was designed to collect data in the aviation maintenance work environment on known factors that affect human fatigue and performance.
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> The FAA's findings suggest that fatigue is an issue in this work force. Data from "mini-logger monitors" that recorded data from the selected parameters of light, noise levels, and temperature; activity monitors that monitored physical activity, sleep, and sleep quality; and answers to background questions that employees were asked clearly indicate that sleep durations are inadequate to prevent fatigue. For most aviation maintenance technician specialties, 30-40 percent of respondents reported sleep durations of less than 6 hours, and 25 percent of respondents reported feeling fatigued or exhausted.
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> The data were intended for use in predicting situations that are conducive to fatigue, accidents, incidents, and errors. Data collection began in August 2000, and the expanded study was planned for completion in December 2003. However, an FAA

Aviation Maintenance Human Factors Project Report from January 2004 stated that the research had not progressed, nor is any broad research effort or regulatory activity currently being conducted in this area.

The FAA has reported to Congress that, based on several studies completed on the maintenance fatigue issue, it believes that the extreme complexity of the issue of maintenance crew fatigue and duty time do not present appropriate material for regulatory activity, and that education and training in fatigue management are the most appropriate actions for the FAA to sponsor and foster. The FAA has consequently conducted education and training activities on fatigue management for aircraft maintenance personnel.

On April 18, 2006, the Safety Board informed the FAA that the Board disagrees with the FAA's positions that regulatory action is not appropriate and that the FAA's current education and training activities related to this issue can achieve the intent of this safety recommendation. On February 22, 2007, the Safety Board informed the FAA that it had reviewed Advisory Circular (AC) 120-72, "Maintenance Resource Management (MRM) Training," which seemed to be the primary focus of the FAA's education and training initiatives related to fatigue among aviation maintenance crews as reported to Congress. The Board found little in AC 120-72 that provides guidance on human fatigue in maintenance crews other than generalized warnings that attention to fatigue is important and should be considered in MRM Training. The AC contains little guidance as to how an employer should design a program to ensure that maintenance crews are not fatigued. The Board asked the FAA whether it has any additional guidance related to fatigue in aviation maintenance crews besides AC 120-72 and whether the FAA will consider establishing duty time limitations for personnel who perform maintenance on air carrier aircraft, as recommended. The FAA has not yet responded. (National Transportation Safety Board, 2009).

## What to do About the Disparity?

This disparity on how to address fatigue complicates the issue even further. On one hand the FAA opines that education and training alone will deter AMT's from working while fatigued. While education and training are important components of a total fatigue management program, they are not in and among themselves going to create a significant reduction in fatigue-related incidents. Simple exhortations such as "don't work when you are tired" or "make sure you get plenty of sleep" are not the solution to the problem.

On the other hand the NTSB recommends that work time limitations via regulation should to be established in order to limit the amount of time that an AMT can work in any given time period. This appears to be a more robust solution, in light of the fact that there are many maintenance organizations pushing their AMT's to work shifts of up to 14-16 hours. Elective overtime may also push the AMT into these hour categories. Empirical research has indicated that people do not perform well in safety-sensitive jobs when a shift is of this duration. The likelihood of committing fatigue-related errors increases significantly.

In order to fully address the ongoing issue of fatigue this author proposes that a conflation of both the FAA and NTSB positions is warranted. A regulation to address working hours coupled with education and training will be the most effective way that industry can address the ongoing fatigue problem.

## Taking Action

Until there is clear guidance on fatigue management, maintenance organizations will be on their own to act on the issue. Some organizations may understand the severity of the problem and act proactively while others may adopt a look and see attitude while others might simply ignore the issue altogether. Assuming the proactive position there are a few steps that organizations can take to at least build a framework for fatigue management. For guidance, however, one may need to look at countries that have consistently been more proactive in safety. For example, Canada tends to be more proactive in addressing the fatigue issue. In fact, unlike the paucity of information available on the FAA website, Transport Canada (TC) (2009) has a rich assortment of information available on fatigue risk management (FRM). Whereas the FAA takes a descriptive approach to fatigue risk management, TC focuses more on a prescriptive approach. The difference being that the FAA puts more emphasis on awareness while TC focuses on palpable countermeasures.

## Limitations and Challenges

Assuming an organization implements a fatigue management system by choice or by mandate there are still a number of limitations and challenges that need to be realized. While this list is far from exhaustive it does highlight a few potential problem areas that should be understood.

First, fatigue is a very subjective phenomenon. There are tests that can accurately determine whether someone is driving under the influence of alcohol. However, there are no scientific tests that can measure whether someone is "working under the influence of fatigue." To compound this issue further, people are not very good at making a self-determination that they are too fatigued to work.

Second, even if there are work hour limits imposed for any given shift there is still no guarantee that the AMT will begin the shift with adequate rest. For instance, if there is an 8 hour maximum shift policy but an AMT arrives at work with only four hours of sleep then there is a good possibility that he or she will be fatigued, even if the shift is only 8 hours in length.

Third, tasks that require focused attention such as visual inspections must include sufficient and strategically scheduled breaks. Vigilance decrement is a form of short-term fatigue that can occur very rapidly when an AMT is conducting a long and tedious task such as a fuselage lap joint inspection (remember Aloha Airlines Flight 243?). Studies indicate that after about 20 minutes an AMT is much less likely to detect obvious defects. In general, inspection tasks that involve variety and regular breaks are less likely to suffer from the vigilance decrement (Hobbs, 2008).

Fourth, assuming a formal fatigue management program is in place, there may still be some questions about the honesty of AMTs using the program. For example, some organizations use an IFLSC (Individual Fatigue Likelihood Score Card). The IFLSC is used to calculate a fatigue score based on the subjective evaluation by the person filling out the card. If the score exceeds a certain threshold then he or she is to report to their manager that they are too fatigued to work safely. Depending on the severity of the fatigue, that person may have a temporary job reassignment or possibly be sent home for the day. The problem with this method is the potential for misuse. Some AMT's may fill out the card in such a way as to feign fatigue in order to satisfy their own agenda. Or, conversely, and more likely, the AMT may be dishonest when filling out the card to indicate that they are not suffering from fatigue when in fact they are. This could occur due to personal pride, peer pressure, and fear of retribution, for instance.

## Conclusion

The purpose of this article was to illuminate some of the complexities and challenges in fatigue management. There is an ongoing disparity between the NTSB and the FAA in relation to promulgating work time regulations aimed at reducing fatigue. In the meantime some organizations have acted proactively and implemented fatigue management programs based on empirical research and best practices. While these programs can be highly effective in mitigating fatigue-related errors there are certain limitations and challenges that may be encountered and will need to be resolved. Although the list was not exhaustive, some important points were discussed in this respect.

In summary, this author opines that the FAA will eventually promulgate work time rules for the aviation maintenance industry. This, combined with a strong fatigue risk management program to include education and training, will be most effective in reducing fatigue-related errors in the aircraft maintenance domain. Until then, you may just be exhorted to "get plenty of sleep." That is problematic to say the least.

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Dr. Robert Baron is the President and Chief Consultant of The Aviation Consulting Group. He performs extensive work in his core specializations of Human Factors (HF), Safety Management Systems (SMS), Crew Resource Management (CRM), and Line Operations Safety Audit (LOSA). He consults with, and provides training to, hundreds of aviation organizations on a worldwide basis.